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Report on the individual review of the inventory submission of Canada submitted in 2014*

* In the symbol for this document, 2014 refers to the year in which the inventory was submitted, and not to the year of publication.

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Contents

		Paragraphs	*Page*
I.	Introduction and summary	1–5	3
II.	Technical assessment of the annual submission	6–85	5
	A. Overview	6–14	5
	B. Energy	15–29	9
	C. Industrial processes and solvent and other product use	30–42	14
	D. Agriculture	43–53	17
	E. Land use, land-use change and forestry	54–69	20
	F. Waste	70–85	24
III.	Conclusions and recommendations	86–87	28
	A. Conclusions	86	28
	B. Recommendations	87	29
Annexes			
I.	Documents and information used during the review		35
II.	Acronyms and abbreviations		37

I. Introduction and summary

1. This report covers the review of the 2014 inventory submission of Canada, coordinated by the UNFCCC secretariat, in accordance with the "Guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention" (hereinafter referred to as the UNFCCC review guidelines). The review took place from 6 to 11 October 2014 in Gatineau, Canada, and was conducted by the following team of nominated experts from the UNFCCC roster of experts: generalist – Mr. Leif Hockstad (United States of America); energy – Mr. Graham Anderson (Germany); industrial processes and solvent and other product use – Mr. Philip Acquah (Ghana); agriculture – Ms. Baasansuren Jamsranjav (Mongolia); land use, land-use change and forestry (LULUCF) – Mr. Mattias Lundblad (Sweden); and waste – Ms. Kaatje Jespers (Belgium). Mr. Hockstad and Ms. Jamsranjav were the lead reviewers. The review was coordinated by Ms. Lisa Hanle (UNFCCC secretariat).

2. In accordance with the UNFCCC review guidelines, a draft version of this report was sent to the Government of Canada which provided comments that were considered and incorporated, as appropriate, into this final version of the report. All encouragements and recommendations in this report are for the next inventory submission, unless otherwise specified.

3. All encouragements and recommendations in this report are for the next inventory submission, unless otherwise specified and are based on the expert review team's (ERT's) assessment of the 2014 annual submission against the UNFCCC review guidelines. The ERT has not taken into account the fact that for the submissions due by 15 April 2015 Parties will report using the revised "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories" adopted through decision 24/CP.19. Therefore, when preparing the next annual submissions, Parties should evaluate the implementation of the recommendations and encouragements in this report, in the context of those guidelines.

4. In 2012, the main greenhouse gas (GHG) emitted by Canada was carbon dioxide (CO_2), accounting for 78.8 per cent of total GHG emissions[1] expressed in CO_2 equivalent (CO_2 eq), followed by methane (CH_4) (13.0 per cent) and nitrous oxide (N_2O) (6.8 per cent). Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) collectively accounted for 1.4 per cent of the overall GHG emissions in the country. The energy sector accounted for 81.0 per cent of total GHG emissions, followed by the industrial processes sector (8.1 per cent), the agriculture sector (7.9 per cent), the waste sector (2.9 per cent) and the solvent and other product use sector (0.04 per cent). Total GHG emissions amounted to 698,626.47 Gg CO_2 eq and increased by 18.2 per cent between the base year[2] and 2012. The ERT concluded that the description in the national inventory report (NIR) of the trends for the different gases and sectors is reasonable.

5. Tables 1 and 2 show GHG emissions under the Convention, by gas and by sector, respectively. In table 1, CO_2, CH_4 and N_2O emissions do not include emissions and removals from the LULUCF sector.

[1] In this report, the term "total GHG emissions" refers to the aggregated national GHG emissions expressed in terms of carbon dioxide equivalent excluding LULUCF, unless otherwise specified.

[2] The base year for Canada is 1990, consistent with the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part 1: UNFCCC reporting guidelines on annual inventories".

Table 1
Greenhouse gas emissions, by gas, 1990 to 2012

	Gg CO_2eq								*Change (%)*
Greenhouse gas	*1990*	*1995*	*2005*	*2008*	*2009*	*2010*	*2011*	*2012*	*1990–2012*
CO_2	459 037.98	490 945.82	576 740.89	576 574.74	542 521.19	554 408.24	557 289.69	550 546.59	19.9
CH_4	72 002.96	85 911.88	98 600.76	94 222.84	90 850.98	88 598.39	88 579.03	90 563.31	25.8
N_2O	49 168.89	53 849.77	50 381.54	51 796.20	47 069.70	47 156.55	45 918.34	47 733.40	–2.9
HFCs	767.25	479.41	5 296.47	5 550.65	6 306.34	7 072.55	7 547.12	7 782.90	914.4
PFCs	6 538.83	5 489.59	3 317.26	2 252.32	2 171.97	1 607.52	1 455.99	1 551.63	–76.3
SF_6	3 392.20	2 395.56	1 492.14	683.95	393.06	459.01	422.21	448.63	–86.8

Table 2
Greenhouse gas emissions by sector, 1990 to 2012

	Gg CO_2eq								*Change (%)*
Sector	*1990*	*1995*	*2005*	*2008*	*2009*	*2010*	*2011*	*2012*	*1990–2012*
Energy	469 183.81	508 784.63	595 033.07	591 816.18	559 954.71	569 551.01	572 926.44	565 758.87	20.6
Industrial processes	55 705.87	57 306.06	60 435.23	58 974.18	51 764.45	54 091.65	54 652.51	56 457.08	1.3
Solvent and other product use	178.71	212.58	378.00	341.62	260.49	241.97	247.40	310.14	73.5
Agriculture	46 832.28	52 769.91	58 210.77	58 345.65	55 633.04	55 085.32	53 035.84	55 528.60	18.6
LULUCF	–71 019.98	196 777.49	53 412.34	–17 211.84	–27 477.24	75 742.90	76 809.17	40 860.25	–157.5
Waste	19 007.45	19 998.86	21 771.98	21 603.07	21 700.55	20 332.32	20 350.18	20 571.78	8.2
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (with LULUCF)	**519 888.13**	**835 849.52**	**789 241.39**	**713 868.86**	**661 836.00**	**775 045.16**	**778 021.55**	**739 486.72**	**42.2**
Total (without LULUCF)	**590 908.11**	**639 072.03**	**735 829.05**	**731 080.70**	**689 313.24**	**699 302.26**	**701 212.37**	**698 626.47**	**18.2**

Abbreviations: LULUCF = land use, land-use change and forestry, NA = not applicable.

II. Technical assessment of the annual submission

A. Overview

1. Annual submission and other sources of information

6. The 2014 annual submission was submitted on 11 April 2014; it contains a complete set of common reporting format (CRF) tables for the period 1990–2012 and an NIR. Canada further submitted a French translation of the NIR on 16 July 2014. The inventory submission was submitted in accordance with the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories" (hereinafter referred to as the UNFCCC reporting guidelines).

7. The full list of materials used during the review is provided in annex I to this report.

2. Overall assessment of the inventory

8. Table 3 contains the ERT's overall assessment of the inventory submission of Canada. For recommendations for improvements for specific categories, please see the paragraphs cross-referenced in the table.

Table 3
The expert review team's overall assessment of the inventory submission

	General findings and recommendations
The ERT's findings on completeness of the 2014 inventory submission	In an earlier draft of this report, the ERT had identified several additional categories for which Canada reported the notation key "NE". The ERT acknowledges Canada's response to the earlier draft and justifications for the incorrect use of the notation key "NE" for PFC emissions from aerosols/metered dose inhalers (Canada indicated it should be "NA"), N_2O emissions from ammonia production (Canada indicated it should be "NA"), N_2O from adipic acid production (Canada indicated it should be "NA" through 2009 when production ceased and thereafter "NO"), and CH_4 emissions from aluminium production (Canada indicated it should be "NA"). The ERT recommends that the Party change these notation keys in the CRF tables and conduct appropriate QA/QC steps on the use of notation keys in the annual submission
Energy, industrial processes, solvent and other product use, agriculture and waste[a]	Not complete	Mandatory: CH_4 emissions from mules and asses (enteric fermentation) (see paragraph 45 below); CO_2 emissions from clinical waste incineration (see paragraph 84 below) The ERT recommends that the Party estimate and report emissions from all mandatory categories

		General findings and recommendations
		Non-mandatory: CO_2 emissions from coal mining and handling; CO_2 and CH_4 emissions from solid fuel transformation; CO_2 emissions from natural gas (other leakage in the residential and commercial sectors); CO_2 emissions from asphalt roofing; CO_2 emissions from road paving with asphalt; CH_4 emissions from ammonia production; CH_4 emissions from steel production; CH_4 emissions from ferroalloys production; potential SF_6 emissions from import, export and destruction; CH_4 emissions from enteric fermentation – poultry; CH_4 emissions from agricultural soils – direct soil emissions and indirect emissions; CO_2 emissions from solid waste disposal on land; N_2O emissions from industrial wastewater; N_2O emissions from domestic and commercial wastewater; and N_2O emissions from clinical waste incineration
		The ERT encourages the Party to estimate and report emissions from all non-mandatory categories
Land use, land-use change and forestry[a]	Not complete	Mandatory: Carbon stock changes (CSC) from all pools in wetlands and settlements converted to cropland; CSC from living biomass and soils in grassland remaining grassland; CSC from living biomass (losses) and soils in cropland and grassland converted to wetlands; CSC from living biomass (losses) in other land converted to wetlands; CSC from living biomass in wetlands and other land converted to settlements; CSC in living biomass and soils in grassland and wetlands converted to other land; and N_2O emissions from mineral soils from disturbance associated with land-use conversion to cropland
		For category-specific recommendations, please see paragraphs 58, 59, 65, 69 below
		The ERT recommends that the Party estimate and report emissions from all mandatory categories
		Non-mandatory: CSC from dead organic matter in grassland remaining grassland; CSC from dead organic matter in cropland and grassland converted to wetlands; CSC from dead organic matter in other land converted to wetlands; CSC from living biomass (gains), dead organic matter and soils in settlements remaining settlements; CSC in dead organic matter and soils in wetlands and other land converted to settlements; CSC in dead organic matter in grassland and wetlands converted to other land; CH_4 and N_2O emissions from biomass burning on land converted to other land; and N_2O emissions from harvested wood products
		The ERT encourages the Party to estimate and report emissions from all non-mandatory categories

		General findings and recommendations
The ERT's findings on recalculations and time-series consistency		
Recalculations	Sufficiently transparent, except for the waste sector.	Please see paragraphs 47 and 72 below for category-specific findings related to the transparency of recalculations
Time-series consistency	Not sufficiently consistent	Please see paragraphs 48, 64 and 76 below for category-specific findings
The ERT's findings on QA/QC procedures	Sufficient	Canada has elaborated a QA/QC plan and has implemented tier 1 QA/QC procedures in accordance with that plan The ERT recommends that Canada implement further QA/QC measures to ensure the consistency of reporting in the NIR and CRF tables. Additionally, the ERT recommends that Canada improve its description on the use of the Canadian Greenhouse Gas Emissions Reporting Program data for QA/QC and verification of the inventory, especially for the relevant sectors and categories Please see paragraphs 17, 47, 50–52, 67 and 72 below for category-specific recommendations
The ERT's findings on the transparency	Sufficiently transparent, except for the waste sector	Please see paragraphs 17, 23, 25, 40, 41, 46, 50, 57, 63, 74, 78, 80–83 below for category-specific recommendations

Abbreviations: CSC = carbon stock changes, CRF = common reporting format, ERT = expert review team, NA = not applicable, NE = not estimated, NIR = national inventory report, NO = not occurring, QA/QC = quality assurance/quality control.

[a] The assessment of completeness by the ERT considers only the completeness of reporting of mandatory categories (i.e. categories for which methods and default emission factors are provided in the Intergovernmental Panel on Climate Change (IPCC) *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* or the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*).

3. Description of the institutional arrangements for inventory preparation, including the legal and procedural arrangements for inventory planning, preparation and management

Inventory planning

9. The NIR and additional information provided by the Party during the review described the institutional arrangements for the preparation of the inventory. As indicated by the Party in its NIR, there were no changes to the inventory planning process. The description of the inventory planning process, as contained in the report of the individual review of the inventory submission of Canada submitted in 2013,[3] remains relevant.

10. During the in-country review, Canada elaborated on its formalized planning process for improvements and shared internal tracking sheets on these planned improvements. The

[3] FCCC/ARR/2013/CAN, paragraphs 12–15.

ERT found that the details provided during the review are far more elaborate than descriptions provided in the NIR on planned improvements. The ERT encourages Canada to provide further clarification on the formalized planning process for inventory improvements, and the manner in which improvements are identified and resources are allocated. The ERT also recommends that Canada provide further details on planned improvements and encourages the Party to provide specific timelines for implementing those improvements.

Inventory preparation

11. Table 4 contains the ERT's assessment of Canada's inventory preparation process. For improvements related to specific categories, please see the paragraphs cross-referenced in the table.

Table 4
Assessment of inventory preparation by Canada

Issue	*Expert review team assessment*	*General findings and recommendations*
Key category analysis		
Was the key category analysis performed in accordance with the IPCC good practice guidance and the IPCC good practice guidance for LULUCF?	Yes	Level and trend analysis performed, including and excluding LULUCF
Approach followed?	Tier 1	
Were additional key categories identified using a qualitative approach?	No	
Does the Party use the key category analysis to prioritize inventory improvements?	Yes	
Assessment of uncertainty analysis		
Approach followed?	Tier 1	Tier 2 conducted for select categories
Was the uncertainty analysis carried out consistent with the IPCC good practice guidance and the IPCC good practice guidance for LULUCF?	No	Canada does not report a trend uncertainty estimate, including LULUCF. Uncertainty estimates as well as total uncertainties are required for all source and sink categories by using the tier 1 method. The ERT reiterates the recommendation made in the previous review report that the Party calculate the trend uncertainty, including LULUCF. Canada generally relies on uncertainty analyses from 2003–2004, which have been updated periodically when methodological updates are made to a category. Please see paragraph 57(b) below for category-specific recommendations

Issue	*Expert review team assessment*	*General findings and recommendations*
Quantitative uncertainty (including LULUCF)	Level = ±6.0%	
	Trend = Canada did not provide this value, owing to the Party's claims of highly variable data in the LULUCF sector	
Quantitative uncertainty (excluding LULUCF)	Level = ±4.0%	
	Trend = 1.1%	

Abbreviations: IPCC good practice guidance = the Intergovernmental Panel on Climate Change (IPCC) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, IPCC good practice guidance for LULUCF = IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, LULUCF = land use, land-use change and forestry, LULUCF = land use, land-use change and forestry.

Inventory management

12. There were no changes to the inventory management process carried out by the Party for the 2014 inventory submission, as indicated by the Party in its NIR. The description of the inventory management process, as contained in the report of the individual review of the annual submission of Canada submitted in 2013[4] remains relevant.

4. Follow-up to previous reviews

13. Several recommendations made in previous review reports have been implemented, leading to improvements to the Party's inventory submission. Canada provides specific information on its responses to review recommendations across all sectors in tabular format in the NIR. Improvements incorporated into the inventory include increasing the transparency of the energy and industrial processes sector by including further details on activity data (AD) (e.g. use of metallurgical coke and other reductants for iron and steel production in the energy and industrial processes and solvent and other product use sectors), as recommended by previous review reports. Additionally, Canada has improved its quality assurance/quality control (QA/QC) procedures for the LULUCF sector and corrected its use of notation keys in the waste sector, based on recommendations made in previous review reports.

14. Recommendations made in previous review reports that have not yet been implemented, as well as issues the ERT identified during the 2014 annual review, are discussed in the relevant sectoral chapters of the report and in table 7.

B. Energy

1. Sector overview

15. The energy sector is the main sector in the GHG inventory of Canada. In 2012, emissions from the energy sector amounted to 565,758.87 Gg CO_2 eq, or 81.0 per cent of total GHG emissions. Since 1990, emissions have increased by 20.6 per cent. The key drivers for the rise in emissions are increases in fuel use for transport across the entire time series and increases in CH_4 emissions from coal mining and handling and oil and gas extraction over recent years. Within the sector, 34.5 per cent of the emissions were from transport, followed by 26.8 per cent from energy industries, 15.1 per cent from manufacturing industries and construction and 12.8 per cent from other sectors. Fugitive

[4] FCCC/ARR/2013/CAN, paragraph 19.

emissions from oil and natural gas accounted for 10.6 per cent and fugitive emissions from solid fuels accounted for 0.2 per cent. The remaining emissions (0.01 per cent) were from other (energy).

16. The Party has made recalculations between the 2013 and 2014 inventory submissions for this sector. The recalculations were made following standard updates in AD for fuel use and production by Statistics Canada across all energy sector categories and changes to the emission factors (EFs) for propane combusted in road transportation to increase accuracy. Compared with the 2013 inventory submission, the recalculations increased emissions in the energy sector by 1,325.03 Gg CO_2 eq (0.2 per cent), and increased total national emissions by 0.2 per cent. The recalculations were adequately explained.

17. A recommendation made in the previous review report was that Canada document the QA/QC procedures undertaken for the energy sector. Although the 2014 NIR refers to QA/QC checks for review of the estimation model, AD, EFs, time-series consistency, transcription errors, reference material, conversion factors and unit labelling, as well as sample emission calculations in the energy sector, the NIR does not document the outcomes of QA/QC procedures. To improve transparency, the ERT reiterates the recommendation made in the previous review report that the Party document QA/QC procedures and outcomes.

18. The previous review report noted that Canada reports some propane and butane as gaseous fuels and some as liquid fuels. For 2012, Canada has reported apparent consumption of propane (130,762.49 TJ) and butane (15,693.19 TJ) in CRF table 1.A(b) under other gaseous fossil fuels, with 231,436.80 TJ of natural gas liquid (NGL) ethane production. According to the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*[5] (hereinafter referred to as the Revised 1996 IPCC Guidelines) ethane, propane and butane should be categorized as liquid fuels even where they do not originate from crude oil. In response to a question raised by the ERT during the review, the Party confirmed that this change in categorization will be implemented in the 2015 inventory submission. NGLs and liquefied petroleum gas (LPG) will both be reported consistently as liquid fuels. The ERT welcomes Canada's efforts and recommends that the Party incorporate these changes in the inventory for the full time series and include information describing these changes in its NIR.

19. Canada uses a range of country-specific natural gas EFs and energy content factors. In response to a question raised by the ERT during the review, the Party stated that each year it receives new energy conversion factors (ECFs) from Statistics Canada to convert volumes of natural gas to energy units. However, the ECFs are only available at the national level and not at the provincial level, and the Party also stated that the natural gas ECF as currently presented in the national energy balance is available only for marketable natural gas. Therefore, the energy value of natural gas for producer consumption (as used by the upstream oil and gas industry) and natural gas supply underestimates the natural gas energy consumed and supplied. The ERT recommends that Canada enhance the transparency of its reporting by documenting how the EFs and ECFs map on to the AD and describe problems associated with obtaining annual provincial ECFs. The ERT further recommends that Canada take steps to ensure that the conversion of volumes of natural gas to energy units be completed appropriately for both marketable and non-marketable natural gas. The ERT recommends that Canada document progress on its efforts in its improvement

[5] Understanding the Common Reporting Framework, page 1.19. Available at <http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ri.pdf>.

plan and in the NIR of future inventory submissions. The ERT encourages Canada to consider a study to develop a time series of regional natural gas ECFs and EFs.

2. Reference and sectoral approaches

20. Table 5 provides a review of the information reported under the reference approach and the sectoral approach, as well as comparisons with other sources of international data. Issues identified in table 5 are more fully elaborated in paragraphs 21–23 below.

Table 5
Review of reference and sectoral approaches

		Paragraph cross-references
Difference between the reference approach and the sectoral approach	Energy consumption: –307.61 PJ, –3.85% CO_2 emissions: –326.20 Gg CO_2 eq, –0.07%	
Are differences between the reference approach and the sector approach adequately explained in the NIR and the CRF tables?	Yes	
Are differences with international statistics adequately explained?	Yes	See paragraph 22 below
Is reporting of bunker fuels in accordance with the UNFCCC reporting guidelines?	Yes	
Is reporting of feedstocks and non-energy use of fuels in accordance with the UNFCCC reporting guidelines?	Yes	

Abbreviations: CRF = common reporting format, NIR = national inventory report, UNFCCC reporting guidelines = "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories".

Comparison of the reference approach with the sectoral approach and international statistics

21. No problems were identified in the comparison of the reference approach with the sectoral approach based on information included in annex 4 of the NIR and information presented to the ERT during the review, and there is a close correlation between the reference approach and the sectoral approach over the time series since 2004. There are, however, constant differences between the approaches at the level of total liquid and total gaseous fuels that tend to compensate each other. CO_2 emissions for liquid fuels from the reference approach since 1990 are on average 2.4 per cent higher than those calculated using the sectoral approach. This compensates for the emission data for natural gas, where the CO_2 emissions from gaseous fuels in the reference approach, since 1990, are on average 3.7 per cent lower than those for the sectoral approach. In response to questions raised by the ERT during the review, the Party provided analysis showing that the planned changes to the allocation of NGLs and LPG, which will be reported as liquid fuels (see para. 18 above), will reduce the difference between the reference approach and the sectoral approach for liquid and gaseous fuels in the next inventory submission. The ERT welcomes the Party's efforts on addressing this issue and notes the effect on improved transparency and

consistency as reflected in the reference approach comparison, and recommends that the Party incorporate these changes in the inventory for the full time series and include information describing these changes in its NIR.

22. There has been a long-standing issue raised in previous review reports regarding the comparison of quantities of fuels reported in the reference approach compared with international statistics. For example, in the review of Canada's 2013 inventory submission,[6] the ERT noted that the apparent fuel consumption reported in CRF table 1.A(c) is lower than that reported to the International Energy Agency (IEA) by up to 9 per cent for all years except 2002 (+1.4 per cent), 2005 (+9.2 per cent), 2006 (+10.3 per cent) and 2010 (0 per cent). In the 2014 inventory submission, a similar disparity can still be observed, where data reported in the CRF tables is lower than that reported to the IEA by up to 13 per cent for all years except 2011 (1.0 per cent) and 2012 (1.9 per cent). During the review, the ERT had the opportunity to review and discuss this matter with Canada along with the related issues raised in previous review reports. The ERT found that the dissimilarities can be attributed to data set timing (monthly and annual, provisional and revised) and possible different conversions from physical fuel units to energy units because the Party uses country-specific energy content factors. Some of the differences can also be attributed to a different national/international split of aviation fuels (see para. 23 below). Taking these matters into account and also considering the high level of consistency in Canada's overall reference approach versus sectoral approach comparison, the ERT concluded that there is no reason for concern raised by the apparent inconsistency with international statistics.

International bunker fuels

23. In 2012, Canada reported 3,540.22 million litres of apparent consumption of jet kerosene in CRF table 1.A(b) for international bunkers. The ERT noted that the figures for jet kerosene for international aviation in the CRF table are more than double those reported to the IEA, but further noted that the IEA figures for domestic aviation for this fuel are higher by comparable quantities. According to the NIR (part 1, page 69), for its inventory submission to the UNFCCC, Canada estimates the amount of jet kerosene used for international aviation bunkers based on the location of the origin and destination airports using its Aviation Greenhouse Gas Emission Model (AGEM). This is in line with the Intergovernmental Panel on Climate Change (IPCC) *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC good practice guidance). During the review, the ERT learned that in the data used by IEA, the split is essentially based on who bought the fuel and the flag of the purchaser. The ERT notes that this is further clarified in the NIR (part 2, page 45) where Canada indicates that, for international reporting requirements to IEA, the Party assumes that all fuel sold to domestic carriers is domestic and all fuel sold to foreign carriers is international, which underestimates aviation bunkers in the IEA statistics. The ERT recommends that the Party include similar text in part 1 of the NIR (e.g. section 3.4.1 or 3.4.1.1) pointing out that the AGEM allocations to international bunkers means that it is not practical to make a direct comparison of the unadjusted data from Statistics Canada with data reported to IEA.

Feedstocks and non-energy use of fuels

24. No problems were identified.

[6] FCCC/ARR/2013/CAN, paragraph 27.

3. Key categories

Stationary combustion: liquid and gaseous fuels – CO_2, CH_4 and N_2O

25. The CO_2 implied emission factor (IEF) for gaseous fuels from manufacture of solid fuels and other energy industries appears high for all years. The IEF for 2012 was 60.95 t/TJ as reported by Canada in terms of gross calorific value (GCV), while the corresponding 2012 IEFs for the United States and Australia (both GCV) are 50.24 t/TJ and 51.15 t/TJ, respectively. On a net calorific value (NCV) basis (67.72 t/TJ) the CO_2 IEF is higher than all reporting Parties (ranging from 54.87–67.72 t/TJ). In response to a question raised by the ERT during the review, the Party stated that the vast majority of emissions in this category result from the combustion of non-marketable natural gas (greater than 95 per cent) by oil and gas production facilities, and that because the non-marketable natural gas contains heavier hydrocarbons, the CO_2 IEF is accordingly higher. The ERT encourages the Party to provide this explanation, including the quantification details, in the NIR.

26. Total emissions from mining and from oil and gas extraction reported under other (manufacturing industries and construction) in 2012 (40,907.77 Gg CO_2 eq) were approximately five times the 1990 value (6,590.08 Gg CO_2 eq). Per-barrel emissions from oil and gas production have been rising, owing to an increase in the complexity of techniques used to produce conventional oil and the ongoing growth of oil production from oil sands (NIR, pages 5 and 6). In response to a question raised by the ERT during the review as to whether Canada has undertaken steps to verify such data, the Party clarified that some of the emissions data reported to Canada's domestic Greenhouse Gas Emissions Reporting Program (GHGRP) are compared with data reported to the UNFCCC as a verification step. Such a verification step has not yet been undertaken for these categories. The ERT encourages Canada to make more use of this approach and document validation and verification practices as part of ongoing QA activities and recommends that the Party include in the NIR details of these verification steps for the applicable energy sector categories.

Road transportation: liquid fuels – CO_2

27. The CO_2 IEF for diesel (69.53 kg/TJ on a GCV basis) has been held constant since 1998. In response to questions raised by the ERT during the review, Canada confirmed that the diesel CO_2 IEF is based on a weighted average of data for all regions and reflecting seasonal variations, available during the development of an earlier study by McCann.[7] Acknowledging the central importance and age of the McCann report, the ERT welcomes the information that Canada is evaluating the opportunities to repeat portions of the study to investigate the evolution and current applicability of the final applied EF. The ERT recommends that Canada carry out this analysis and document progress on this in its improvement plan and in the NIR.

Navigation: liquid fuels – CO_2, CH_4 and N_2O[8]

28. Canada reports that fuels sold to foreign marine vessels are assumed to be used only for international travel and the associated emissions are reported separately under international bunkers, while fuels sold to Canadian vessels are assumed to be used for domestic navigation. However, according to the NIR (part 1, page 69) it has become apparent that some Canadian vessels are engaged in international marine travel, and that

[7] TJ McCann and Associates Ltd and Clearstone Engineering Ltd. March 2000. *1998 Fossil Fuel and Derivative (CO_2 per Unit of Fuel and Heating Values) Factors*. Prepared for Pollution Data Branch, Environment Canada. Final Draft.

[8] CH_4 and N_2O emissions from this category are not key. However, since all issues related to this category are discussed as a whole, the individual gases are not assessed in separate sections.

data which would allow separate allocation of fuel to domestic and international navigation are currently unavailable (NIR, part 2, page 47) but are being investigated (NIR, part 1, page 59). The ERT notes that the availability of such data would enable accurate disaggregation of domestic and international navigation in accordance with the IPCC good practice guidance. The ERT recommends that Canada report on the progress of these investigations and, if new data become available, revise the emission estimates for the entire time series.

Oil and natural gas: liquid fuels – CH_4

29. Fugitive CH_4 emissions from the category oil, natural gas and other sources increased from 1,365.34 Gg in 1990 to 2,145.15 Gg in 2012, an increase of 57.1 per cent. This category includes emissions associated with crude bitumen extracted from oil sands. Fugitive emissions from oil sands production are calculated using the Clearstone bitumen model, based on a report prepared by Clearstone Engineering Ltd for the Canadian Association of Petroleum Producers (CAPP).[9] The ERT understands that, given the size and importance of this category, Canada is assessing the feasibility of conducting an updated bitumen study. The ERT recommends that Canada continue to explore ways to review and update the model to capture industry changes and document progress on this in its improvement plan and in the NIR.

C. Industrial processes and solvent and other product use

1. Sector overview

30. In 2012, emissions from the industrial processes sector amounted to 56,457.08 Gg CO_2 eq, or 8.1 per cent of total GHG emissions, and emissions from the solvent and other product use sector amounted to 310.14 Gg CO_2 eq, or 0.04 per cent of total GHG emissions. Since 1990, emissions have increased by 1.3 per cent in the industrial processes sector, and increased by 73.5 per cent in the solvent and other product use sector. The key driver for the increase in emissions is the growth in HFC emissions from consumption of halocarbons resulting from the substitution of ozone depleting substances under the Montreal Protocol over the period, notwithstanding declining PFC emissions in aluminium production and plant closures (magnesium and adipic acid production ceased in 2008 and 2009, respectively). Additionally, all categories were affected by the 2008–2009 economic downturn in Canada, with some increases in emissions since 2010, notably CO_2 emissions from the categories mineral products and metal production and the country-specific category other (industrial processes), which includes the subcategory other and undifferentiated production. Within the industrial processes sector in 2012, 29.7 per cent of the emissions were from other (industrial processes), followed by 28.9 per cent from metal production and 14.8 per cent from mineral products. Consumption of halocarbons and SF_6 accounted for 14.2 per cent of emissions. The remaining 12.4 per cent were from chemical industry. Canada reports the notation key "NA" (not applicable) for other production and production of halocarbons and SF_6.

31. Canada has made recalculations between the 2013 and 2014 inventory submissions for the industrial processes sector. The two most significant recalculations made by Canada between the 2013 and 2014 inventory submissions were in the following categories: CO_2 emissions from mineral products and other (industrial processes). The recalculations were made following the submission of actual AD to replace provisional values extrapolated for the previous inventory submission and notably revised AD for non-energy use of fuels from

[9] CAPP. 2006. *An Inventory of GHGs, CACs, and H_2S Emissions by the Canadian Bitumen Industry: 1990 to 2003.*

1996 to 2003. The ERT also notes that Canada carried out recalculations in order to improve time-series consistency in the reporting of HFC, PFC and SF_6 emissions from the consumption of halocarbons and SF_6, based on preliminary data obtained from Environment Canada and in response to recommendations made in previous review reports.

32. Compared with the 2013 inventory submission, the recalculations increased emissions in the industrial processes sector by 381.22 Gg CO_2 eq (0.7 per cent), and increased total national emissions by 0.1 per cent. The recalculations were adequately explained in the NIR.

33. The previous review report noted that indirect GHG emissions (carbon monoxide, nitrogen oxides, non-methane volatile organic compounds and sulphur oxides) are reported in the CRF tables as "IE" (included elsewhere). The estimated emissions are reported in the NIR (annex 10, table 10-1) in accordance with the nomenclature for reporting sectors to the Convention on Long-range Transboundary Air Pollution. The ERT reiterates the encouragement in the previous review report that Canada report indirect GHG emissions in the CRF tables in future inventory submissions.

34. The ERT commends Canada for the collection and reporting of AD for non-energy uses of fuels by type (solid, liquid, gaseous). The ERT notes that this practice has facilitated the consistent and transparent estimation and allocation of the emissions relating to non-energy use of fuels in the industrial processes sector with the appropriate subtraction from the energy sector, in accordance with the IPCC good practice guidance, to avoid double counting. The ERT notes that the Revised 1996 IPCC Guidelines considers this to be a notoriously difficult area for inventory compilers. The ERT recommends that the Party consider the underlying AD further and whether there is an opportunity for further disaggregation of the category other (industrial processes) (see para. 41 below).

2. Key categories

Cement production – CO_2

35. Recommendations in previous review reports included that Canada develop a country-specific EF based on plant-level data for the calcium oxide (CaO) content in clinker, largely determined by the characteristics of the limestone/ore deposits in Canada, and a plant-specific cement kiln dust (CKD) correction factor. In the 2014 inventory submission, Canada continued to use the methodology of estimating CO_2 emissions from cement production using the tier 2 approach, but using the default EF from the Revised 1996 IPCC Guidelines (0.5071 kt CO_2/kt clinker produced) and a default CKD correction factor of 1.02. In response to questions raised by the ERT during the review, Canada indicated that it is currently examining plant-level data obtained from the Cement Association of Canada. Additional confidential information, provided by the Party during the review in response to questions raised by the ERT, confirmed that the plant-level data have been collected from some of the clinker plants. The ERT notes that the large number of operating plants in Canada provides the Party with the opportunity to develop and report a weighted average EF. The ERT therefore recommends that Canada evaluate the plant-level data further and, as appropriate, develop a country-specific EF and CKD value. The ERT further recommends that Canada appropriately document the development of these factors in the NIR.

Iron and steel production – CO_2

36. The ERT commends the Party for addressing the recommendations made in the previous review report relating to transparency. Specifically, Canada provided additional information on iron and steel production processes in 17 iron and steel facilities, consisting of 5 major integrated iron and steel plants and 12 non-integrated mills, by Canadian province.

37. A new set of emission parameters, reflecting circumstances specific to Canada, has been used to develop the 1990–2012 estimates (i.e. a country-specific CO_2 EF for coke, an updated carbon content of pig iron, and carbon content of pig iron used for steelmaking). The study results provided the required data for the application of the tier 2 method in the IPCC good practice guidance. The study also improved transparency by identifying and allowing the reporting of the non-energy use of other reductants (such as coal) in addition to metallurgical coke for iron and steel production. However, Canada allocated emissions from the non-energy use of the other identified reductants to the energy sector or other (industrial processes) because they are currently not disaggregated in the energy statistics. The ERT recommends that Canada include the allocation of non-energy use of other reductants identified in this category in its improvement plan (see para. 41 below) to further disaggregate the energy statistics and other (industrial processes) category in future inventory submissions.

Aluminium production – PFCs

38. The ERT commends the Party for providing additional information on the plant-specific AD and EFs in its 2014 NIR to improve transparency, in response to the recommendations made in the previous review report. During the review, Canada confirmed that out of a total of 12 plants, 11 plants use tier 3 methods based on plant-specific data to estimate PFCs, and one plant uses a tier 2 method based on default EFs. The plant-specific AD, EFs and the tier 3 methodologies provided by the Aluminium Association of Canada (AAC) have been facilitated by mandatory reporting regulations on GHGs for provinces. Under a memorandum of understanding signed in 2012 between Environment Canada and AAC, Environment Canada receives the data provided by AAC member companies under the reporting regulations. The ERT finds that the reporting for this category is consistent with the IPCC good practice guidance but encourages Canada to increase the transparency of its calculations for this category by including in the NIR the information shared with the ERT during the review.

Consumption of halocarbons and SF_6 – HFCs, PFCs and SF_6

39. The previous review report noted that Canada reported values for AD and IEFs in CRF table 2(II)F for all categories but that emissions from the background tables were reported as "IE". The previous review report recommended that Canada increase the accuracy, transparency and comparability of its reporting of HFC emissions in this category by developing country-specific EFs. During the previous review, in response to questions raised by the ERT, Canada indicated that, in 2011, a study had been undertaken to implement the improvement plan to determine country-specific HFC EFs, and that the results of that study were planned to be incorporated in the 2014 inventory submission. The ERT notes, and welcomes, the inclusion of more disaggregated emissions information in the 2014 inventory submission, which has enabled the Party to separately report emissions from manufacturing, stocks and disposal for relevant categories.

40. Based on information shared during the review week, the ERT notes that the success of the data collection has been facilitated by Environment Canada's mandatory data reporting regulations promulgated and enforced under the Federal Halocarbon Regulations, 2003, for the production and consumption of HFCs, PFCs and SF_6. The ERT notes that Canada has carried out recalculations and improved time-series consistency in the reporting of HFCs, PFCs and SF_6 emissions from the consumption of the halocarbons and SF_6 based on the preliminary data obtained from the industry-specific mandatory reporting regulations. However, Canada is yet to complete the processing and the development of country-specific EFs that should enable Canada to improve its estimates and report emissions for all halocarbons and SF_6, which are currently aggregated and reported as "IE" (e.g. from fire extinguishers, aerosols, solvents and semiconductors). The ERT recommends

that Canada continue its work on incorporating the results of this study into the inventory, and continue to improve the transparency and comparability of its inventory and reporting in response to recommendations made in previous review reports.

Other (industrial processes) – CO_2 and CH_4

41. The category is country-specific, comprising all non-energy uses of solid, liquid and gaseous fuels as feedstock not allocated to identifiable IPCC categories, particularly for metal, chemical and petrochemical processes. The category is key because it is highly aggregated and includes CO_2 emissions from ethylene, sinter production and ferroalloys production, which would be expected to be reported as "IE" in the industrial processes sector according to the UNFCCC reporting guidelines, as well as other activities (e.g. use of lubricants such as engine oil and grease in transportation). The ERT notes the improvement in the documentation of the category in the 2014 NIR in response to recommendations made in previous review reports, and further notes that Canada includes a short overview of methods and calculations of emissions for all subcategories and feedstocks included in the category other (industrial processes). Nevertheless, the ERT finds that the lack of disaggregation into the identifiable subcategories has resulted in a lack of transparency because of the reporting of several categories and gases as "IE" (e.g. ethylene, sinter and ferroalloys) and a high level of uncertainty resulting from the use of bulk AD and aggregate EFs. The ERT commends Canada for its commitment, expressed during the review, to improve reporting for this category. The ERT recommends that Canada implement the scheduled improvements for this category, reporting on progress in future inventory submissions, and continue the improvements necessary to document the methods and sources of AD and EFs in the NIR.

3. Non-key categories

Lime production – CO_2

42. In response to recommendations made in the previous review report, Canada has provided additional information in its inventory submission on AD for the production of high-calcium and dolomitic lime. Specifically, Canada indicated that the AD presented in the CRF tables in 2011 comprised the total national lime production, which included the water content of the hydrated lime. The AD in the 2014 CRF tables have therefore been recalculated on a 'dry' basis for the entire time series. Canada also obtained and reported the share of dolomitic and high-calcium lime in the lime production category and provided an explanation for the large decline in the share of dolomitic lime in the 1999–2000 and 2008–2009 periods. During the review, in response to questions raised by the ERT, Canada attributed the decline to the decommissioning of a dolomitic lime plant in 2000 and to the change in production of only dolomitic lime to both dolomitic and high-calcium lime in another plant. The ERT encourages Canada to include this information in the NIR to increase the transparency of the information on trends for this category.

D. Agriculture

1. Sector overview

43. In 2012, emissions from the agriculture sector amounted to 55,528.60 Gg CO_2 eq, or 7.9 per cent of total GHG emissions. Since 1990, emissions have increased by 18.6 per cent. The key drivers for the rise in emissions are the expansion of the beef cattle and swine populations, and increases in the application of synthetic nitrogen (N) fertilizers. Within the sector, 56.8 per cent of the emissions were from agricultural soils, followed by 31.6 per cent from enteric fermentation and 11.5 per cent from manure management. The remaining 0.1 per cent was from field burning of agricultural residues. Emissions from rice cultivation

were reported as "NA", "NO" (not occurring); emissions from prescribed burning of savannas were reported as "NO" and from other (agriculture) were reported as "NA".

44. Canada has made recalculations between the 2013 and 2014 inventory submissions for this sector. The two most significant recalculations made by Canada between the 2013 and 2014 inventory submissions were in the following categories: enteric fermentation (CH_4) and agricultural soils (N_2O). The recalculations were made following changes in AD based on the 2011 Census of Agriculture, owing to revisions to animal population estimates by Statistics Canada and revisions to crop areas by Agriculture and Agri-Food Canada (AAFC), as well as an improvement to ecodistrict-level climate data. Compared with the 2013 inventory submission, the recalculations decreased emissions in the agriculture sector by 889.15 Gg CO_2 eq (1.6 per cent), and decreased total national emissions by 0.1 per cent. The recalculations were not adequately explained (see para. 47 below).

45. Previous review reports recommended that Canada provide further documentation that mules and asses are not occurring, or if they are occurring, use default methods to estimate CH_4 emissions or report these emissions as "NE" (not estimated). Canada retained the notation key "NO" in its 2014 inventory submission. In response to questions raised by the ERT during the review, Canada explained that populations of mules and asses have not been compiled by Statistics Canada because they have not been reported in the 2011 Census of Agriculture in sufficient numbers to be considered an agricultural livestock category. The ERT reiterates the recommendation made in the previous review report that Canada provide further documentation that these animals are not occurring, and if they are occurring, use default methods to estimate emissions or report "NE", as appropriate.

2. Key categories

Enteric fermentation – CH_4

46. Canada uses the IPCC tier 2 approach to estimate CH_4 emissions from cattle and the IPCC tier 1 approach for non-cattle animal categories. A default methane conversion rate (Ym) of 4 per cent from the IPCC good practice guidance is used for non-dairy cattle in feedlots to calculate CH_4 EFs. The NIR states that total mixed rations for cattle are assumed to be mainly forage and grain. However, according to the IPCC good practice guidance, the 4 per cent should be used for feedlot-fed cattle when the fed diets contain concentrates amounting to 90 per cent or more. In response to the questions raised by the ERT during the review, Canada explained that the beef industry in Canada has an intensive finishing stage for meat production. During this period, slaughter animals are fed a diet of as much concentrate and grain silage as possible, to gain maximum weight. The 4 per cent is used for animals that are in the intensive finishing stage before slaughter. For all other production stages the 6 per cent value from the IPCC good practice guidance is used. The ERT recommends that Canada provide an explanation on the use of the IPCC default value in the NIR to improve transparency.

47. In the NIR, explanations for the recalculations of emissions from enteric fermentation and manure management refer to table 6-4 of the NIR. However, the ERT noted that the table does not present any data for enteric fermentation and manure management. In response to questions raised by the ERT during the review, Canada provided a revised table and explained that there was a production error in the final stages of layout of the NIR. The ERT recommends that Canada fix the error and provide a corrected table in the NIR.

48. The NIR states that, because of the identification of anomalous values for bulls in the published data, the value for live weight (carcass weight is used as an indicator) used in 2012 was the same as that used in 2011, because the Party is awaiting a complete review of the data published on the AAFC website. In response to questions raised by the ERT during

the review, Canada explained that the issue was reviewed and it was found that there was an error in the website tool; the website has since been corrected and therefore the time series will be complete and consistent in the Party's 2015 inventory submission. The ERT recommends that Canada use the updated live weight data for bulls in its inventory submission.

49. During the review, Canada informed the ERT that some minor animal categories, such as deer and elk, will be included in the 2015 inventory submission. The ERT welcomes this effort by Canada to enhance the completeness of its inventory and encourages the Party to include these animal categories in its inventory submission.

Manure management – CH_4 and N_2O

50. Canada uses the tier 2 method of the IPCC good practice guidance to estimate CH_4 emissions from manure management and a tier 1 method to estimate N_2O emissions. The NIR states that the maximum methane-producing potential (B_0) and methane conversion factor (MCF) values from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the 2006 IPCC Guidelines) are used for all animals. Table A8-24 of the NIR presents MCF values by animal categories and manure management systems and explains that the values are from tables 10A-5–10A-9 of the 2006 IPCC Guidelines. The MCF values provided in the NIR (table A8-24) for poultry are 0.2 (liquid systems), 0.015 (solid storage and dry lot), 0.015 (pasture, range and paddock) and "NA" (other systems), while table 10A-9 of the 2006 IPCC Guidelines provides MCF values for poultry by five poultry subcategories, but not by manure management systems. No explanation was provided in the NIR to describe how these values from the 2006 IPCC Guidelines were applied. Furthermore, the values provided in NIR table A8-24 for poultry are different from those in CRF table 4.B(a). Specifically, in NIR table A8-24 "NA" is reported for the MCF of other systems, whereas in CRF table 4.B.(a) an MCF value of 0.01 was reported. During the review, the Party explained that the study (Marinier et al., 2004)[10] that determined manure management systems in Canada identified liquid manure systems for laying hens and pasture systems (free range poultry) for turkeys and some broilers. According to that study, lagoons (i.e. anaerobic treatment lagoons) are not used for storing poultry manure, instead the storage systems are either storage tanks under the barn, or concrete or steel holding tanks exterior to the barn. Therefore, the MCF value of 0.2 for cool climate that was used for swine and dairy liquid manure storage systems was used for liquid systems for poultry and a default value of 0.015 from the 2006 IPCC Guidelines is used for solid storage and dry lot. The Party explained that the differences between NIR table A8-24 and CRF table 4.B(a) result from the varying regional distributions of poultry and varying distributions among the different poultry subcategories and also to the rounding of some values in NIR table A8-24, and these will be corrected in its 2015 inventory submission. The ERT recommends that Canada provide an explanation for the MCF value used for poultry in the NIR to improve transparency and correct the transcription errors found to ensure consistency of data in the NIR and CRF tables.

51. During the review, the ERT found that the percentages of animal waste management systems presented in CRF table 4.B(a) are different from those given in NIR table A3-24 (e.g. the CRF table reports 42.85, 39.69, 17.35 and 0.11 for liquid system, solid storage, pasture, range and paddock and other systems for dairy cattle, respectively, while the corresponding NIR table presents 39, 43, 18 and 0 for liquid system, solid storage and dry lot, pasture, range and paddock, and other systems, respectively). Furthermore, the sum of

[10] Marinier M, Clark K and Wagner-Riddle C. 2004. *Improving Estimates of Methane Emissions Associated with Animal Waste Management Systems in Canada by Adopting an IPCC Tier 2 Methodology.* Final report submitted to the Greenhouse Gas Division, Environment Canada, by the Department.

the values for solid storage and pasture, range and paddock in CRF table 4.B(a) for goats exceeds 100 per cent. In response to the questions raised by the ERT during the review, Canada explained that the sum that exceeds 100 per cent results from a transcription error that occurred in transferring data to the CRF tables; one value was updated and not the other. The Party also informed the ERT that table A3-24 of the NIR will be revised. The ERT recommends that Canada address the observed inconsistencies in the NIR and CRF tables, and correct the transcription error found in the CRF table.

Direct soil emissions – N_2O

52. A country-specific tier 2 method is used to estimate N_2O emissions from manure applied as fertilizer. The amount of N excretion (59.5 kg N/head/year) for buffalo (North American bison that are raised for meat production) given in table A3-29 of the NIR for the animal manure N applied as fertilizer (59.50 kg N/head/year) is different from the value reported in CRF table 4.B(b) (54.66 kg N/head/year). Although a constant value of N excretion (54.66 kg N/head/year) is reported in the CRF tables for buffalo, body weight has been increasing over time: from 562.69 kg in 1990 to 624.51 kg in 2012 (CRF table 4.B(a)). In response to the questions raised by the ERT during the review, Canada stated that the inconsistencies observed in buffalo weights used for N excretion, and in the CH_4 and N_2O estimates, will be addressed in the 2015 inventory submission. The ERT recommends that Canada address the observed inconsistencies and provide revised estimates in its inventory submission.

53. Canada currently uses the IPCC tier 1 methodology to estimate N_2O emissions from manure on pasture, range and paddock. The NIR states that research on collecting N_2O flux data from pasture, range and paddock in eastern and western Canada has been carried out since 2009 and the results from this project will be used to provide country-specific EFs to be implemented in Canada's next inventory submission. The ERT commends Canada for this ongoing work to develop country-specific EFs, which will enhance the accuracy of the inventory, and encourages Canada to use the country-specific EFs in its inventory submission.

E. Land use, land-use change and forestry

1. Sector overview

54. In 2012, net emissions from the LULUCF sector amounted to 40,860.25 Gg CO_2 eq. Since 1990, when the sector was a net sink (–71,019.98 Gg CO_2 eq), net removals have decreased by 157.5 per cent. There is no specific trend in the total estimate for the LULUCF sector as it is mainly influenced by large inter-annual variations due to the episodic nature of wildfires in forests (see para. 60 below). Within the sector, 4,929.28 Gg CO_2 eq of net removals were from cropland. Net emissions were reported from forest land (32,097.64 Gg CO_2 eq), from settlements (9,776.86 Gg CO_2 eq), from wetlands (2,536.91 Gg CO_2 eq) and from grassland (1,378.13 Gg CO_2 eq). Emissions from other land and other (LULUCF) were reported as "NE, NO" and "IE, NE", respectively.

55. Canada has made recalculations between the 2013 and 2014 inventory submissions for this sector. The two most significant recalculations made by Canada between the 2013 and 2014 inventory submissions were in the following categories: forest-related categories (forest land remaining forest land, land converted to forest land, cropland, wetlands and settlements) and croplands. The recalculations in forest-related categories were made to correct errors in the CBM-CFS-3 (Carbon Budget Model of the Canadian Forest Sector) model, which is used to calculate carbon stock changes (CSC) for most of the forest-related carbon pools, related to multi-component growth curves, to capture updates to natural disturbance monitoring data sets, to incorporate the most up-to-date provincial forest

information and update AD. The recalculations in croplands were made because of updates to cropland management practice data from the 2011 Census of Agriculture. Compared with the 2013 inventory submission, the recalculations decreased emissions in the LULUCF sector by 10,457.89 Gg CO_2 eq (12.0 per cent) for 2011. The recalculations were adequately explained in the NIR.

56. In the current inventory submission, Canada has made improvements following recommendations made in previous review reports relating to the documentation in the NIR of the QA/QC system for many of the reported categories. Canada has also made some progress towards reporting all mandatory pools and areas by reporting burning of managed grassland for the entire time series with the use of the default IPCC EFs. In the current inventory submission, Canada has also provided justification for the fact that there are no significant differences in above-ground biomass before and after grassland conversion to cropland, as recommended in the previous review report. The ERT commends Canada for its efforts in making the reporting of the sector more complete.

57. Generally, the NIR and the corresponding annexes are well written. All categories are presented in a systematic and clear way. However, the ERT recommends that Canada improve transparency in the following areas:

(a) The default transition time (20 years) is used for the reporting of most of the land-use change categories, while the methods used to calculate the corresponding CSC are often based on longer periods of transition from one equilibrium to another. Canada explained during the review how these methods are applied for CSC in land-use change categories and how the corresponding carbon sock changes are allocated in the CRF tables. This is not always properly explained in the NIR and therefore the ERT recommends that Canada include more information clarifying that transition times (20 years) for the allocation of CSC in the CRF tables are more procedural than related to the processes involved in the emissions calculations;

(b) Uncertainties are described for all categories and quantified for most categories (except wetlands and settlements). However, while the total uncertainty of the sector is included in the total level estimate of uncertainty for Canada's GHG inventory, no overall uncertainty assessment for the sector is included in the sectoral part of the NIR. The ERT therefore recommends that Canada provide a summary table including all uncertainties that have been calculated, including the overall uncertainty of the sector, in the NIR of its inventory submission;

(c) In some categories, the estimates in the CRF tables comprise emissions or removals from different subcategories (e.g. peat extraction and flooding under wetlands or subdivisions under forest land converted to settlements) making it difficult to assess the relative impact of each subcategory. Therefore, the ERT encourages Canada to consider whether reporting subcategories for some categories (see examples above) may be relevant and if so, then the current division into reporting zones is necessary.

58. The ERT noted that the total reported area decreases over time that is, by 1 per cent from 1990 (284,493.02 kha) to 2012 (281,497.25 kha). In response to questions raised by the ERT during the review, Canada indicated that the reason for the decrease is that it currently does not report areas or CSC for categories where CSC do not occur (or are not estimated). However, in the NIR, Canada states that the practice for reporting is that once land has been reported it cannot leave reporting. While the ERT acknowledges Canada's concern that such reporting may lead to misunderstandings in the interpretation of IEFs related to the use of areas in the CRF tables that do not correspond exactly to reduced CSC estimates, the ERT encourages Canada to improve the completeness for representing land areas in the LULUCF sector, by amending the reporting (both the land-use change matrix and the category-specific CRF tables) by including all land areas and making it clear which

categories and subcategories do exist and whether the emissions/removals are calculated or not. This includes both managed land areas where no emissions/removals are expected (for instance grassland remaining grassland) as well as unmanaged areas.

59. As pointed out in previous review reports, Canada reports several categories using the notation key "NE". Currently "NE" is used for all carbon pools in wetlands and settlements converted to cropland; grassland remaining grassland; cropland, wetlands and other land converted to settlements; and grassland and wetlands converted to other land. Living biomass and dead organic matter are not reported in cropland and grassland (as well as some subcategories under other land uses) converted to wetlands. Losses in living biomass and net CSC in dead organic matter and soil are not reported in settlements remaining settlements. For some of the above-mentioned categories (wetlands and settlements converted to cropland, living biomass for grassland remaining grassland, settlements remaining settlements, cropland and wetlands converted to settlements) "NE" is indeed the relevant notation key because the emissions or removals are known to occur in Canada but are not estimated, but when a category does not exist or cannot occur, as pointed out in the responses by Canada to questions raised by the ERT during the review (e.g. grassland and wetlands converted to other land, and cropland and grassland converted to wetlands) the ERT recommends that Canada use the notation key "NO". Finally, "IE" could be used instead of "NE" for losses in CSC in living biomass for other land converted to wetlands because these losses apparently are included in the soil organic carbon changes, as noted by Canada in response to questions raised by the ERT during the review. In cases where no country-specific data are available, tier 1 default approaches should be used. The ERT reiterates the recommendation made in previous review reports that Canada improve the completeness of its reporting of the pools in the above-mentioned mandatory subcategories currently reported as "NE" and include a description on how notation keys have been used. The ERT also encourages Canada to report emissions from all non-mandatory categories.

2. Key categories

Forest land– CO_2, CH_4 and N_2O

60. The main drivers of the net removals in CSC in living biomass are growth, harvest and other disturbances (wildfires, insect attacks). While growth and harvest levels are more or less stable over time, disturbances due to wildfires are stochastic and insect attacks occur in more of a cyclical nature. During the review, Canada provided more details on the different processes (gains and losses due to disturbances) involved in the estimate of net removals which increased the ERT's understanding of the large inter-annual variations in CSC in forest land. For instance, carbon losses from the biomass pool resulting from wildfires fluctuate by up to 65,455.9 Gg carbon among years. To increase transparency, the ERT encourages Canada to include this information for the entire time series in the NIR.

61. Carbon stock changes in organic soils are not separately reported from mineral soils under forest land because the model used currently cannot separate the processes involved. Consequently, Canada does not report emissions of CO_2 from organic soils under forest land, or emissions of N_2O in CRF table 5(II). In response to questions raised during the review, Canada indicated that organic forest soils exist but also stated that drainage is not a current management practice in Canada. Canada also provided information on the development of the CBM-CFS-3model, which will enable it to incorporate organic soils in future estimates. As these soils can be important forest carbon stocks in Canada, the ERT encourages Canada to intensify the work on the model to include organic soil methods and to include separate estimates for CSC in organic soils and mineral soils as soon as these estimates are available. The ERT recommends that Canada provide evidence that drainage

does not occur on forest land and consider whether the notation key "NE" should be used instead of "NO" for emissions of CH_4 or N_2O.

62. Although the pools included and the processes involved in the model used for forest-related categories (CBM-CFS-3) are well described in the NIR and its annex, the ERT found that the use of graphics to illustrate the processes and model could be improved. Such illustration is important to give the reader of the NIR a quick introduction to the model structure and the understanding of how the processes included in the model are connected. The ERT therefore encourages Canada to improve the graphical description of the structure of the CBM-CFS-3 model in the NIR, including references to IPCC carbon pools.

63. The accuracy of the overall carbon budget for forest-related categories modelled with CBM-CFS-3 corresponds well to estimated values (a bias of 1 per cent was reported). However, according to information provided in response to questions raised by the ERT during the review, the correspondence differs among pools. For example, the bias in dead wood was above 50 per cent in the example provided by Canada. No information on pool level accuracy is currently included in the NIR. The ERT therefore recommends that Canada provide further numerical examples on verification activities of the CBM-CFS-3 model at the pool level, as well as pool-specific uncertainties in its NIR.

64. Canada describes in the NIR that different data sources have been used to estimate the occurrence of wildfires. In the 2014 inventory submission, data sets covering the periods 1990–2003 (Canadian National Fire Database) and 2004–2012 (National Burned Area Composite) are used for the quantification of wildfires. No information on the comparability between the data sets has been included in the NIR. In response to questions raised by the ERT during the review, Canada provided additional information that confirms that the two data sets are comparable, but that the accuracy of the latter is better owing to several new methods. The ERT recommends that Canada provide information on these comparisons in its NIR to confirm that data for wildfire quantification is consistent over the reported time series.

Land converted to cropland – CO_2

65. For forest land converted to cropland, Canada reported both AD and changes in carbon stocks as confidential ("C") in the reporting zone of "Boreal Cordillera", but noted in the documentation box to CRF table 5.B that emissions do occur but have not been quantified. According to the UNFCCC reporting guidelines, confidential emissions are to be reported, but may need to be reported at a level of aggregation so as to protect confidential information.[11] In response to questions raised by the ERT during the review, Canada indicated that it would try to find a solution to quantify and incorporate these emissions/removals without exposing the confidential information. The ERT reiterates the recommendation made in the previous review report that Canada find a solution to include the emissions/removals previously not included for confidentiality reasons in its inventory submission.

66. For land converted to cropland, the ERT noted that the method described in the NIR implies a loss of carbon from the soil organic carbon pool owing to the conversion from forest land to cropland. However, the ERT noted that in CRF table 5.B Canada reports a CSC in mineral soils of 7,251.86 Gg C for 2012. In response to questions raised by the ERT during the review, Canada explained that the total CSC in the soil organic carbon pool is also dependent on input from the dead organic matter pool. Additionally, an error was detected by Canada in the transfer of carbon from the dead organic matter pool. While the

[11] FCCC/CP/2002/8, paragraph 27.

ERT finds the explanation by Canada to be valid, the description in the NIR (see for instance figure A3-22) indicates that the carbon transfer (gain) into the pool at the time of transfer only counts for about 20 per cent of the carbon lost until the new equilibrium has been reached. The ERT therefore recommends that Canada: evaluate the method used; consider how to combine the results from the CBM-CFS-3 model and the equation for carbon loss (equation A3-66) used in the estimates; and clearly explain in the NIR which components are included in the estimates.

67. The ERT identified a mismatch in areas between land converted to cropland under CRF table 5.B (419.28 kha) and land converted to cropland under CRF table 5(III) (850.62 kha). In response to questions raised by the ERT during the review, Canada confirmed that the value reported under CRF table 5.B is correct. Canada also confirmed that the corresponding emissions of N_2O from disturbance associated with land-use conversion to cropland are correct (0.04 Gg N_2O). The ERT recommends that Canada enhance the QA/QC process when transferring data into the reporting tables.

Wetlands – CO_2

68. Emissions in the wetlands category include emissions from peat extraction and from flooding. Both are reported together under both wetlands remaining wetlands and land converted to wetlands. While both subcategories are well described in the NIR it is not clear to what magnitude they contribute to the final estimate. The conversion time used also differs (20 years for peat extraction and 10 years for flooding, respectively). For this category, the ERT considers that disaggregating the data into the subcategories peat extraction and flooding may be more informative for readers of the report. To improve the transparency of the reporting on the contribution from these sources the ERT encourages Canada to report the estimates from peat extraction and flooding separately in the CRF tables or clearly display the numbers in the NIR.

3. Non-key categories

Grassland remaining grassland – CO_2

69. Although there were recommendations made in previous review reports, CSC for grassland remaining grassland and land converted to grassland are still not reported. However, areas for grassland remaining grassland are presented in the NIR (5,408 kha). Canada explained during the review, in response to a question raised by the ERT, that the reason for not reporting any change in soil carbon stock from managed grassland is mainly owing to the non-availability of a consistent time series of AD on changes in management practices that affect soil carbon stocks. According to the Canadian definition, it is impossible to have forest land converted to managed grassland because managed grassland excludes areas where forest can grow. However, the exclusion of the other land use conversion categories to grassland are not clearly explained. To improve the completeness, the ERT recommends that Canada report the areas for grassland and report "NE" or "NO" for emissions/removals as appropriate, including information to explain the respective use of notation keys.

F. Waste

1. Sector overview

70. In 2012, emissions from the waste sector amounted to 20,571.78 Gg CO_2 eq, or 2.9 per cent of total GHG emissions. Since 1990, emissions have increased by 8.2 per cent. The key driver for the rise in emissions is population growth. Within the sector, 91.9 per cent of the emissions were from solid waste disposal on land, followed by 4.9 per cent from

wastewater handling. The remaining 3.3 per cent were from waste incineration. Emissions from other (waste) were reported as "NA".

71. Canada has made recalculations between the 2013 and 2014 inventory submissions for this sector. The most significant recalculations made by Canada between the 2013 and 2014 inventory submissions were in the following category: managed waste disposal on land. The recalculations were made following changes in AD, in order to rectify identified errors and following changes in CH_4 recovery data. Compared with the 2013 inventory submission, the recalculations decreased emissions in the total waste sector by 1,395.95 Gg CO_2 eq (6.4 per cent), and decreased total national emissions by 0.2 per cent. The recalculations were not adequately explained (see para. 72 below).

72. Across the waste sector the ERT noted inconsistencies between the descriptions of the recalculations in the NIR and the data in the CRF tables. For example: the NIR (part 1, page 169) mentions that recalculations were undertaken to account for revised population statistics for municipal solid waste (MSW) incineration. According to the NIR, the recalculations increased CH_4 emissions in the order of 0.01 per cent and 0.7 per cent compared with the 2013 inventory submission. However, the ERT calculated a decrease between 0.01 per cent and 4.1 per cent. Further, in the NIR (part 1, page 166), Canada describes the use of a biennial survey for 1990–2011 that contains actual measured facility data on CH_4 emissions from industrial wastewater treatment plants. The NIR states that for 2012 no data were available and therefore CH_4 emissions and recovery were assumed constant from 2011. However, constant CH_4 emissions (0.30 Gg) and recovery (14.40 Gg) are reported for the period 2009–2012 in CRF table 6.B, which is not consistent with the information provided in the NIR. The ERT reiterates the recommendation made in the previous review report that Canada improve the consistency in reporting recalculations in the NIR and CRF tables.

73. Canada reported CH_4 recovered for energy purposes from solid waste disposal on land in the energy sector, although Canada does not report CH_4 recovered for energy purposes from wastewater handling and waste incineration in the energy sector. In response to a question raised by the ERT during the review, and referring to the recommendation made in the previous review report, Canada expressed its intention to reallocate emissions from energy recovery to the energy sector in the next inventory submission. The ERT notes that the current practice is not consistent with the IPCC good practice guidance. The ERT reiterates the recommendation made in the previous review report that Canada report all emissions related to energy recovery in the energy sector.

74. Following a recommendation made in the previous review report, Canada included waste export data in its 2014 inventory submission. In response to questions raised by the ERT during the review regarding a general overview of solid waste amounts in Canada, the Party provided the amounts of waste generated, waste disposal (landfill and incineration) and waste diversion (recycling and composting) occurring in Canada. The ERT commends Canada for including the waste export data in the NIR and for the additional information provided during the review. The ERT recommends that Canada include a detailed overview of waste streams, including at least the information provided to the ERT during the review, in the NIR to improve transparency.

2. Key categories

Solid waste disposal on land – CH_4

75. Waste composition values (degradable organic carbon (DOC)) are kept constant between 1990–2012 for estimating CH_4 emissions from MSW disposal sites in Canada (NIR, part 2, annex 3, tables A3-53). During the review, the ERT learned that several diversion programmes have been introduced, which would have an effect on waste

composition. Canada indicates in the NIR that it intends to update the DOC values for MSW by 2016. The ERT commends Canada for its efforts to develop new DOC values and encourages Canada to evaluate the results for incorporation into the inventory submission, if appropriate.

76. Canada's AD for estimating CH_4 emissions from wood waste landfills (i.e. the amount of wood waste that is landfilled) are available for the period 1970–1992 and for 1998 and 2004. For the years in between, a linear regression trend is used to estimate the amounts. From 2005 onwards no AD are available and Canada estimates the amounts of wood waste landfilled using an exponential (negative) growth function, starting from 2004 data (to 2012). The ERT recommends that Canada provide a justification for using this trend and to conduct detailed checks at intervals to confirm the continued validity of the trend.

77. Canada describes in its NIR an equation for the linear relation between the methane generation rate constant (k) and precipitation. This results in a different k value per province and time series and is based on a study from Research Triangle Institute (RTI)[12] for the United States, resulting in three precipitation levels with related k values. Canada also uses the relationship for precipitation outside the (minimum–maximum) levels of the RTI study and makes the assumption that the waste composition and conditions (availability of nutrients, pH) on landfills in Canada is similar to the waste sampled by RTI in the United States and that the influence of ambient temperature should not be considered at depths exceeding two metres. During the review, Canada could not provide documentation to substantiate some of the assumptions made. The ERT commends Canada for its efforts to develop a country-specific k, but reiterates the recommendation made in the previous review report that Canada provide adequate justification for using country-specific values for the United States as a basis for the Canadian-specific values. The ERT recommends that Canada justify the use of a linear function between k values and precipitation values for values between the three precipitation levels from the RTI study (rather than only making use of the three values, as the United States does). In addition, the use of k values outside the margins of the data in the RTI study should be reduced to the maximum and minimum levels from the RTI study, unless Canada can provide documented justification for going outside of this range. In addition, the ERT recommends that Canada provide justification for the assumption that the waste composition in the Canadian landfills is similar to the waste of the landfills sampled in the RTI study.

78. The amounts of landfill gas recovery for combustion and flaring purposes in the estimation of CH_4 emissions from MSW disposal sites are, in the early years (1983–1996), obtained from ad hoc telephone surveys conducted by Environment Canada. During the review, the ERT requested that Canada provide documentation on the data gathered from the ad hoc surveys and on the method used for estimating the site-specific CH_4 recovery by the survey respondents. Canada provided the ERT with a list of CH_4 recovery data from the individual landfill sites for the years 1990 and 1995. For the years in between, and for 1996, Canada was not able to provide documentation on the methodology used by the individual landfill sites for estimating the CH_4 recovery, and the ERT notes that this is insufficient documentation to demonstrate the methods used to quantify CH_4 recovery and is therefore not consistent with the IPCC good practice guidance. The ERT recommends that Canada document the source of and the methods used to estimate the CH_4 recovery values for 1990–1996. In the absence of such justification, the ERT recommends that Canada assume no recovery for the 1990–1996 period.

[12] Research Triangle Institute (RTI). September 2004. *Documentation for Changes to the Methodology for the Inventory of Methane Emissions from Landfills.*

79. Canada uses an oxidation value of zero in the estimation of CH_4 emissions from solid waste disposal sites, but does not report the justification for the choice of this value in the NIR. In response to questions raised by the ERT during the review, Canada indicated its intention to include the information in the next inventory submission. The ERT encourages Canada to improve the transparency on the justification of this parameter in the methodology for estimating CH_4 emissions from solid waste disposal sites.

3. Non-key categories

Wastewater handling – CH_4 and N_2O

80. In the NIR (part 2, page 152) Canada states: "The percentage of wastewater that is treated aerobically[13] for each province is derived from the product of the percentage of rural population (AECOM Canada 2011) and the population of the province or territory." In response to a question raised by the ERT during the review regarding clarification of the AD for estimating CH_4 emissions from domestic and commercial wastewater handling, Canada noted that the description in the NIR does not correctly reflect the AD used. The ERT recommends that Canada correct the description in the NIR to improve the transparency of the AD used.

81. The previous review report recommended that Canada improve the transparency of the methods used in this category by providing more information on the wastewater treatment systems and their linkage with the parameters used for calculating the EF (e.g. fractions of facilities per type/technique and justification for the parameters used, such as MCF and B_0 for domestic and commercial wastewater handling). The ERT noted that the information in the 2014 NIR was not revised regarding this matter. In response to questions raised by the ERT during the review, Canada provided a study from AECOM Canada Ltd[14] to the ERT. The ERT examined the study and commends Canada's efforts for the justification of the chosen values for the parameters MCF and B_0. The ERT recommends that Canada include a detailed overview of waste streams and of wastewater treatment discharge pathways in the NIR to improve transparency and to underpin the use of the selected EFs. The ERT also encourages Canada to investigate further possibilities to disaggregate the national level AD used (population) in line with the different treatment systems used. Finally, the ERT also encourages Canada to investigate whether the organic load per capita per day (biochemical oxygen demand $(BOD)_5$ of 0.06 kg/capita/day), as suggested by the AECOM report,[15] could be incorporated in the Party's inventory as a country-specific value.

82. Canada assumes that urban municipalities are partly serviced by anaerobic wastewater treatment systems that have full capture of the biogas that is utilized or flared with near complete combustion (NIR, part 2, page 152). Canada clarifies that there are no data available on these treatment plants and so assumes a 100 per cent efficient combustion/flaring and that no CH_4 emissions occur. The ERT notes that additional information on the wastewater treatment facilities (e.g. number, types, with or without energy recovery by combustion, flaring) would better support Canada's assumptions. The ERT reiterates the recommendation made in the previous review report that Canada justify the assumptions for the complete combustion and flaring to improve the transparency of the inventory.

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[13] The ERT believes that this should be read as 'anaerobically'.

[14] Environment Canada. April 2011. *Improved Methodology for the Estimation of Greenhouse Gases from Canadian Municipal Wastewater Treatment Facilities*. AECOM Canada Ltd. Project number. 60116073. Environment Canada, K8A46-09-0031.

[15] Report referred to in footnote 14 above, paragraph 3.1.8.1.

Waste incineration – CO_2, CH_4 and N_2O

83. Canada does not use the same source of data for the composition of MSW for landfills as for MSW incineration. In response to questions raised by the ERT during the previous review, Canada provided the justification for the use of different waste composition values between the categories of solid waste disposal on land and waste incineration. In many Canadian waste incinerators a triage is performed to remove waste fractions that are not accepted for destruction by incineration. Therefore, the waste composition used for estimating emissions from waste incineration is based on a source that provides country-specific composition for wastes actually being incinerated. In response to questions raised by the ERT during the current review, Canada indicated its intention to add this justification to the NIR. The ERT reiterates the recommendation made in the previous review report that Canada provide the justification for not using the same source for the composition of landfilled MSW and incinerated MSW, for transparency reasons.

84. The previous review report[16] recommended that Canada estimate emissions and include information on the missing types of waste in the category of waste incineration. In response to questions raised by the ERT during the previous and current review processes, Canada explained that part of the amount of clinical waste incineration (incinerated in dedicated clinical waste incinerators) was not included in the estimates for this category. The part of clinical waste incinerated in MSW-incinerators (together with the municipal solid waste) is included in the emission inventory. The ERT recommends that Canada improve the completeness of the inventory by estimating the CO_2 emissions from clinical waste incineration in dedicated clinical waste incinerators. Further, the ERT encourages Canada to estimate N_2O emissions from clinical waste incinerated in dedicated waste incinerators.

Other (waste) – CH_4 and N_2O

85. Canada has commercial waste composting facilities in operation, but does not estimate emissions from this category. During the review, Canada clarified that it intends to estimate emissions from commercial composting sites. Canada explained that AD are collected but QA/QC procedures have yet to be performed on those AD. The ERT welcomes the efforts of Canada to collect data on waste diversion (composting).

III. Conclusions and recommendations

A. Conclusions

86. Table 6 summarizes the ERT's conclusions on the 2014 inventory submission of Canada, in accordance with the UNFCCC review guidelines.

Table 6
Expert review team's conclusions on the 2014 inventory submission of Canada

	Paragraph cross-references for identified problems
The ERT concludes that the inventory submission of Canada is not complete with regard to categories and gases, but is complete for years and geographical boundaries and contains both an NIR and CRF tables for 1990–2012	

[16] FCCC/ARR/2013/CAN, paragraph 84.

		Paragraph cross-references for identified problems
Energy, industrial processes, solvent and other product use, agriculture and waste[a]	Not complete	Table 3
Land use, land-use change and forestry[a]	Not complete	Table 3
The ERT concludes that the inventory submission of Canada has been prepared and reported in accordance with the UNFCCC reporting guidelines	Yes	
The Party's inventory is in accordance with the Revised 1996 IPCC Guidelines, the IPCC good practice guidance and the IPCC good practice guidance for LULUCF	Generally	See Table 4 and paragraphs 18, 28, 73 and 78
The institutional arrangements continue to perform their required functions	Yes	

Abbreviations: CRF = common reporting format, ERT = expert review team, IPCC = Intergovernmental Panel on Climate Change, IPCC good practice guidance = IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, IPCC good practice guidance for LULUCF = IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, NIR = national inventory report, Revised 1996 IPCC Guidelines = *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, UNFCCC reporting guidelines = "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories".

[a] The assessment of completeness by the ERT considers only the completeness of reporting of mandatory categories (i.e. categories for which methods and default emission factors are provided in the IPCC *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* or the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*).

B. Recommendations

87. The ERT identified the issues for improvement listed in table 7. All recommendations are for the next inventory submission, unless otherwise specified.

Table 7
Recommendations identified by the expert review team

Sector	*Category/cross-cutting issue*	*Recommendation*	*Reiteration of previous recommendation?*	*Paragraph cross-references*
Cross-cutting	Completeness	Change the notation keys for PFC emissions from aerosols/metered dose inhalers, N_2O emissions from ammonia production and CH_4 emissions from aluminium production in the CRF tables and conduct appropriate QA/QC steps on the use of notation keys	No	Table 3
		Estimate and report emissions from all mandatory categories for the LULUCF sector	Yes	Table 3
	QA/QC	Implement further QA/QC measures to ensure the consistency of reporting in the NIR and CRF tables	No	Table 3

Sector	*Category/cross-cutting issue*	*Recommendation*	*Reiteration of previous recommendation?*	*Paragraph cross-references*
		Improve description of the use of the Canadian Greenhouse Gas Emissions Reporting Program data for QA/QC and verification of the inventory, especially for the relevant sectors and categories	No	Table 3
	Inventory planning	Provide further details on planned improvements	No	10
	Uncertainty	Calculate the trend uncertainty, including LULUCF	Yes	Table 4
Energy	Sector overview	Document QA/QC procedures and outcomes for the sector	Yes	17
		Report emissions from propane and butane as liquid fuels, and transparently describe the changes to the time series in the NIR	Yes	18, 21
		Document how the EFs and ECFs map to the AD and describe problems associated with obtaining annual provincial ECFs, documenting progress in the improvement plan	No	19
		Ensure that all marketable and non-marketable natural volumes are converted to energy units appropriately, documenting progress in the improvement plan	No	19
	International bunker fuels	Document in part 1 of the NIR that the Aviation Greenhouse Gas Emission Model allocations to international bunkers means that it is not practical to make a direct comparison of the unadjusted data from Statistics Canada with data reported to IEA	Yes	23
	Stationary combustion: liquid and gaseous fuels – CO_2, CH_4 and N_2O	Include in the NIR details of the verification steps implemented using the Canadian Greenhouse Gas Emissions Reporting Program data for the applicable energy sector categories	No	26
	Road transportation: liquid fuels – CO_2	Evaluate opportunities to investigate the evolution and current applicability of the final applied EF and document progress on this in the improvement plan and the NIR	No	27
	Navigation: liquid fuels – CO_2, CH_4	Report on the progress of the investigation of the availability of data to allow separate	Yes	28

Sector	*Category/cross-cutting issue*	*Recommendation*	*Reiteration of previous recommendation?*	*Paragraph cross-references*
	and N_2O	allocation of fuel to domestic and international navigation, and, if new data become available, revise the emission estimates for the entire time series		
	Oil and natural gas: liquid fuels – CH_4	Continue to explore ways to review and update the model to capture industry changes and document progress on this in the improvement plan and in the NIR	No	29
Industrial processes and solvent and other product use	Sector overview	Consider the underlying AD further and whether there is an opportunity for further disaggregation of the category other (industrial processes)	Yes	34
	Cement production – CO_2	Evaluate the plant-level data further and, as appropriate, develop a country-specific EF and CKD value and provide documentation in the NIR	Yes	35
	Iron and steel production – CO_2	Include the allocation of non-energy use of other reductants in the improvement plan to further disaggregate the energy statistics and other (industrial processes) category in future inventory submissions	No	37
	Consumption of halocarbons and SF_6 – HFCs, PFCs and SF_6	Continue work to incorporate the results of the study to develop country-specific HFC EFs into the inventory and continue to improve the transparency and comparability of the inventory and reporting	Yes	40
	Other (industrial processes) – CO_2 and CH_4	Implement the scheduled improvements for this category to disaggregate emissions, reporting on progress in future inventory submissions, and continue the improvements necessary to document the methods and sources of AD and EFs in the NIR	Yes	41
Agriculture	Sector overview	Provide further documentation that mules and asses are not occurring, and if they are occurring, use default methods to estimate emissions or report "NE", as appropriate	Yes	45
	Enteric fermentation – CH_4	Provide an explanation for the use of an IPCC default value for the methane conversion rate for non-dairy cattle in the NIR	No	46
		Amend the reference to table 6-4 and provide a corrected table in the NIR	No	47

Sector	*Category/cross-cutting issue*	*Recommendation*	*Reiteration of previous recommendation?*	*Paragraph cross-references*
		Use the updated live weight data for bulls	No	48
	Manure management – CH_4 and N_2O	Provide an explanation for the MCF value used for poultry in the NIR and correct the transcription errors found	No	50
		Address the observed inconsistencies in the NIR and CRF tables and correct the transcription error found in the CRF table for animal waste management systems	No	51
	Direct soil emissions – N_2O	Address the observed inconsistencies for between the NIR and the CRF tables for the amount of N applied as fertilizer	No	52
LULUCF	Sector overview	Include more information clarifying that transition times (20 years) for the allocation of carbon stock changes in the CRF tables are more procedural than related to the processes involved in the emission calculations	No	57(a)
		Provide a summary table including all uncertainties that have been calculated, including the overall uncertainty of the sector, in the NIR	No	57(b)
		Use the notation key "NO" when a category does not exist or cannot occur	Yes	59
		Improve the completeness of reporting of the pools currently reported as "NE" and include a description on how notation keys have been used	Yes	59
	Forest land – CO_2, CH_4 and N_2O	Provide evidence that drainage does not occur on forest land and consider whether the notation key "NE" should be used instead of "NO" for emissions of CH_4 or N_2O	No	61
		Provide further numerical examples on verification activities of the CBM-CFS-3 model at the pool level, as well as pool-specific uncertainties	No	63
		Provide information on the comparisons of data sets used to estimate occurrence of wildfires to confirm that data for wildfire quantification is consistent over the reported time series	No	64
	Land converted to	Find a solution to include the emissions/removals previously not	Yes	65

Sector	*Category/cross-cutting issue*	*Recommendation*	*Reiteration of previous recommendation?*	*Paragraph cross-references*
	cropland – CO_2	included for confidentiality reasons		
		Evaluate the method used; consider how to combine the results from the CBM-CFS-3 model and the equation for carbon loss used in the estimates; and clearly explain in the NIR which components are included in the estimates	No	66
		Enhance the QA/QC process for transferring data into the reporting tables	No	67
	Grassland remaining grassland – CO_2	Report the areas for grassland and report "NE" or "NO" for emissions/removals as appropriate, including information to explain the respective use of notation keys	Yes	69
Waste	Sector overview	Improve the consistency in reporting recalculations in the NIR and CRF tables	Yes	72
		Report all emissions related to energy recovery in the energy sector	Yes	73
		Include a detailed overview of waste streams, including at least the information provided to the ERT during the review, in the NIR	No	74
	Solid waste disposal on land – CH_4	Provide a justification for using a linear regression trend for CH_4 emissions from wood waste landfills and conduct detailed checks at intervals to confirm the continued validity of the trend	No	76
		Provide adequate justification for using country-specific values for the United States as a basis for the Canadian-specific values for k	Yes	77
		Justify the use of a linear function between k values and precipitation values for values between the three precipitation levels from the RTI study (rather than only making use of the three values, as the United States does)	No	77
		Provide justification for the assumption that the waste composition in the Canadian landfills is similar to the waste of the landfills sampled in the RTI study	No	77
		Document the source of and the methods used to estimate the CH_4 recovery values for 1990–1996. In the absence of such justification, assume no recovery for the	No	78

Sector	*Category/cross-cutting issue*	*Recommendation*	*Reiteration of previous recommendation?*	*Paragraph cross-references*
		1990–1996 period		
	Wastewater handling – CH_4 and N_2O	Correct the description in the NIR to improve the transparency of the AD used for estimating CH_4 emissions from domestic and commercial wastewater	No	80
		Include a detailed overview of waste streams and of wastewater treatment discharge pathways in the NIR to improve transparency and to underpin the use of the selected EFs	Yes	81
		Justify the assumptions for the complete combustion and flaring	Yes	82
	Waste incineration – CO_2, CH_4 and N_2O	Provide justification for not using the same source for the composition of landfilled MSW and incinerated MSW	Yes	83
		Estimate CO_2 emissions from clinical waste incinerated in dedicated waste incinerators	No	84

Abbreviations: AD = activity data, CBM-CFS-3 = Carbon Budget Model of the Canadian Forest Sector, CKD = cement kiln dust, CRF = common reporting format, ECF = energy conversion factor, EF = emission factor, IEA = International Energy Agency, k = methane generation rate constant, LULUCF = land use, land use change and forestry, MCF = methane conversion factor, MSW = municipal solid waste, N = nitrogen, NE = not estimated, NO = not occurring, NIR = national inventory report, QA/QC = quality assurance / quality control, RTI = Research Triangle Institute.

Annex I

Documents and information used during the review

A. Reference documents

Intergovernmental Panel on Climate Change. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>.

Intergovernmental Panel on Climate Change. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*. Available at <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>.

Intergovernmental Panel on Climate Change. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Available at <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>.

Intergovernmental Panel on Climate Change. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. Available at <http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.htm>.

"Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories". FCCC/SBSTA/2006/9. Available at <http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf>.

"Guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention". FCCC/CP/2002/8. Available at <http://unfccc.int/resource/docs/cop8/08.pdf>.

Status report for Canada 2014. Available at <http://unfccc.int/resource/docs/2014/asr/can.pdf>.

Synthesis and assessment report on the greenhouse gas inventories submitted in 2014. Available at <http://unfccc.int/resource/webdocs/sai/2014.pdf>.

FCCC/ARR/2013/CAN. Report of the individual review of the inventory submission of Canada submitted in 2013. Available at <http://unfccc.int/resource/docs/2014/arr/can.pdf>.

B. Additional information provided by the Party

Responses to questions during the review were received from Ms. My Chau Thai, Ms. Jackie Mercer and Mr. Lindsay Pratt (Environment Canada), including additional material on the methodology and assumptions used. The following documents[1] were also provided by Canada:

Bona, K.A., J. Fyles, C. Shaw, W. Kurz. 2013. *Are Mosses Required to Accurately Predict Upland Black Spruce Forest Soil Carbon in National-Scale Forest C Accounting Models?* Ecosystems (2013) 16: 1071–1086 DOI: 10.1007/s10021-013-9668-x.

[1] Reproduced as received from the Party.

Environment Canada. Landfill Gas Survey. Form.

Environment Canada. September 2014. Tracking sheets for ERT recommendations and planned improvement.

Environment Canada. April 2011. Improved Methodology for the Estimation of Greenhouse Gases from Canadian Municipal Wastewater Treatment Facilities. AECOM Canada Ltd. Project number. 60116073. Environment Canada K8A46-09-0031.

Environment Canada. September 2014. Quality Assurance and Quality Control Plan: For Canada's Greenhouse Gas Inventory. Version 3.3. Pollutant Inventories and Reporting Division.

Environment Canada. September 2014. Quality Manual. Pollutant Inventories and Reporting Division.

Shaw, C.H., A.B. Hilger, J. Metsaranta, W.A. Kurz, G. Russo, F. Eichel, G. Stinson, C. Smyth, M. Filiatrault. 2014. *Evaluation of simulated estimates of forest ecosystem carbon stocks using ground plot data from Canada's National Forest Inventory.* Ecological Modelling 272 (2014) 323–347.

Statistics Canada. 2008. Waste Management Industry Survey: Business and Government Sectors. Catalogue no 16F0023X. Published by the Minister responsible for Statistics Canada.

Statistics Canada. 2010. Waste Management Industry Survey: Business and Government Sectors. Catalogue no 16F0023X. Published by the Minister responsible for Statistics Canada.

Statistics Canada. January 2014. Report on Energy Supply and Demand in Canada: 2012 Preliminary. Published by the Minister responsible for Statistics Canada. Available at <http://www5.statcan.gc.ca/olc-cel/olc.action?objId=57-003-X&objType=2&lang=en&limit=0>.

Statistics Canada. February 2014. Report on Energy Supply and Demand in Canada: 2012 Preliminary. Published by the Minister responsible for Statistics Canada. Available at <http://www5.statcan.gc.ca/olc-cel/olc.action?objId=57-003-X&objType=2&lang=en&limit=0>.

Stinson, G., W.A. Kurz, C.E. Smyth, E.T. Neilson, C.C. Dymond, J.M. Metsarantaz, C. Boisvenue, G.J. Rampley, Q.Li, T.M. White and D. Blain. 2011. *An inventory-based analysis of Canada's managed forest carbon dynamics, 1990 to 2008.* Global Change Biology. 17, 2227–2244, doi: 10.1111/j.1365-2486.2010.02369.x.

Teodoru, C. R., et al. 2012. *The net carbon footprint of a newly created boreal hydroelectric reservoir*, Global Biogeochem. Cycles, 26, GB2016, doi:10.1029/2011GB004187.

The Athena Institute. 1993. Cement and Structural Concrete. LCI Update. Table 6.2 and Table 7.3.

The Athena Institute. 2005. Cement and Structural Concrete. LCI Update 2005. Table 6.2 and Table 7.3.

Tremblay, A. J. Therrien, B. Hamlin, E. Wichmann and Lawrence J. LeDrew. 2005. GHG Emissions from Boreal Reservoirs and Natural Aquatic Ecosystems.

T.J. McCann and Associates Ltd and Clearstone Engineering, Ltd. March 2000. *1998 Fossil Fuel and Derivative (CO_2 per Unit of Fuel and Heating Values) Factors*. Prepared for Pollution Data Branch, Environment Canada. Final Draft.

Annex II

Acronyms and abbreviations

AD	activity data
B_0	methane producing potential
C	confidential
CH_4	methane
CKD	cement kiln dust
CSC	carbon stock change
CO_2	carbon dioxide
CO_2 eq	carbon dioxide equivalent
CRF	common reporting format
DOC	degradable organic carbon
ECF	energy conversion factor
EF	emission factor
ERT	expert review team
GCV	gross calorific value
GHG	greenhouse gas; unless indicated otherwise, GHG emissions are the sum of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 without GHG emissions and removals from LULUCF
HFCs	hydrofluorocarbons
IE	included elsewhere
IEA	International Energy Agency
IEF	implied emission factor
IPCC	Intergovernmental Panel on Climate Change
k	methane generation rate constant
kg	kilogram (1 kg = 1,000 grams)
kha	kilohectare
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MCF	methane conversion factor
MSW	municipal solid waste
N	nitrogen
N_2O	nitrous oxide
NA	not applicable
NCV	net calorific value
NE	not estimated
NGL	natural gas liquid
NIR	national inventory report
NO	not occurring
PFCs	perfluorocarbons
PJ	petajoule (1 PJ = 10^{15} joule)
QA/QC	quality assurance/quality control
SF_6	sulphur hexafluoride
TJ	terajoule (1 TJ = 10^{12} joule)
UNFCCC	United Nations Framework Convention on Climate Change